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Standard Test Method for Measurement of Suspended Sediment Removal Efficiency of Hydrodynamic Stormwater Separators and Underground Settling Devices[1]

This standard is issued under the fixed designation C1746/C1746M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method concerns measurement of the efficiency of hydrodynamic separators and underground settling devices in removing suspended sediment from simulated stormwater runoff under conditions defined herein. This test method is not intended for use in determining field removal efficiency.

1.2 Units tested shall be of a size commonly manufactured, not a scale model. This test method is not intended to address product scaling.

1.3 This test method is not for measuring the removal efficiency of filters or the scouring potential of hydrodynamic separators and underground settling devices.

1.4 In this test method, only gravity flow operation is addressed—performance of units operating under pressurized conditions is not addressed.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D422 Test Method for Particle-Size Analysis of Soils

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D4959 Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *inlet (or outlet) rounding, n*—radius of fillet at inside pipe junction with separator structure.

4. Summary of Test Method

4.1 This test method describes procedures and equipment to measure the suspended sediment removal efficiency of hydrodynamic separators and underground settling devices used for treating stormwater runoff.

5. Significance and Use

5.1 Each device has unique flow patterns and turbulence characteristics and may exhibit a wide range of efficiencies as discharge, particle-size distribution, particle density, and flow viscosity (that is, water temperature) changes. The testing procedures described in Section 8 provide a method of measuring the removal efficiency of these devices under a given flow condition, flow viscosity (water temperature), and particle-size distribution and density. Therefore, the results of testing represent the flow, viscosity, and particle-size distribution tested.

6. Apparatus

6.1 The experimental setup includes an influent straight pipe (without bends or fittings) of minimum length equivalent to ten pipe diameters or 6 m [20 ft], whichever is less, upstream from the test unit and effluent pipe length equivalent to three pipe diameters with a free-fall condition at its downstream end. Pipe shall have a Manning's roughness coefficient not greater than 0.013.

6.2 The test unit shall be set up to reflect actual field installation parameters to the greatest degree possible, including inlet/outlet roundings as supplied or recommended by the manufacturer.

[1] This test method is under the jurisdiction of ASTM Committee C27 on Precast Concrete Products and is the direct responsibility of Subcommittee C27.70 on Precast Concrete Products for Stormwater Management.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6.3 Influent and effluent pipe diameters shall be the minimum size recommended by the manufacturer and shall be documented in test results, as well as pipe orientation and pipe slopes (2 to 3 %).

6.4 The sediment injection point shall be at the crown of the influent pipe at a distance equal to 2 ± 0.1 pipe diameters along the centerline of the pipe upstream of the inlet to the treatment device to supply the sediments in the simulated stormwater runoff.

6.5 The sediment delivery system (feeder) shall be comprised of suitable means of sediment addition so as to provide consistent sediment feed rate of solids (including an auger, vibratory hopper, well-mixed slurry injection system, or other).

6.6 A flow meter shall be installed to measure the water flow rate through the test unit.

6.7 All components of the experimental setup shall be inspected immediately before any testing to confirm that no damage or obstruction is present and that there are no sediments or other deleterious materials therein. No leakage in system piping or from the unit is allowed during the test.

7. Sampling

7.1 Sampling of the sediment delivery system is intended to quantify the average influent concentration. Six feed rate samples shall be taken from the feeder at of the injection point, at evenly spaced intervals over the total duration of the test. Each sample shall be collected in a clean preweighed plastic 1-L [1.06-qt] container over an interval timed to the nearest 1 s.

7.2 Feed rate samples shall be a minimum 100 cm^3 [6.10 in^3] or collection interval shall not exceed 1 min, whichever comes first. Samples shall be dried, weighed to the nearest 1 g [0.002 lb] and recorded. The feed rate coefficient of variation (COV) shall not exceed 0.10.

7.3 The influent concentration of each sample shall be computed from Eq 1:

$$C_{\text{inf}} = \frac{W_{sample}}{\Delta t\ Q\ g} \tag{1}$$

where:

C_{inf} = influent concentration,
W_{sample} = dry weight of each sample,
Q = measured flow rate,
Δt = sampling duration,
g = gravitational acceleration.

8. Procedure

8.1 *Suspended Solids:*

8.1.1 The specific gravity of the particles shall be assessed before the test using Test Method D854. The particle-size distribution shall be determined according to Test Method D422 using standard sieves conforming to Specification E11.

8.1.2 For each test, a minimum of 10 kg [22 lb] of material shall be fed into the influent pipe. The suspended solids concentration shall be within the range of 50 to 300 mg/L [8.35 × 10^{-4} to 2.50 × 10^{-3} lb/gal] as determined from feed rate sampling in 7.1.

8.1.3 "Recirculated" water that passes through the test unit shall not be redirected into the system until it has been filtered completely through a 53-µm (270 US mesh) or finer filter (Note 1) such that it is indistinguishable from the original water for the purposes of this test.

NOTE 1—If feed material contains fractions less than 75 µm [0.003 in.], recirculated water shall be filtered through a 25-µm (550 US mesh) filter.

8.1.4 If river water is used, the river intake shall be high enough above the riverbed such that no inorganic materials are withdrawn from the river.

8.1.5 Water routed only once through the system, or "flow-through" water (that is, river water), shall elicit a background sediment concentration test. The background concentration test shall consist of running water through the device at 10 % of the maximum tested flow rate without feeding any sediments into the system for a period of 1 h. After the 1-h period, the device shall be drained and the solids removed by the device shall be collected, dried, and sieved as described in 8.3. If the particles are very small, that is, smaller than 53 microns, then the concentration should be determined from hydrometer analysis. The background concentration for each particle size shall then be estimated using the formula:

$$C = \frac{W}{t\ Q\ g} \tag{2}$$

where:

C = background concentration,
t = duration,
W = weight of the measured solids,
g = gravity, and
Q = flow rate set at 10 % of the maximum tested flow rate.

8.1.6 For computing the removal efficiency of a particle size, the background concentration of that particle size shall be added to the feeding concentration of each test.

8.1.7 Test flow shall be measured, maintained, and recorded at a defined constant rate and shall vary by no more than 3 % throughout the test.

8.2 *Water Temperature*—Tests shall be run at 18 to 23°C [64 to 74°F]. See Note 2. At a minimum, water temperatures in the sump of the test unit shall be recorded three times, at the beginning, the middle, and the end of each test. The average temperature shall be used in data reporting.

NOTE 2—Tests may be run outside of specified temperature range with a clearly stated deviation from the test method included in results (explicitly indicate temperatures as tested).

8.3 *Test Procedure:*

8.3.1 Dry and determine moisture content of a well-mixed feed sample in accordance with Test Method D4959. Cool the feed sample to room temperature and store in a dessicator until used. To obtain an accurate measurement of the mass of sediments fed into the system, the sediment feeder shall be emptied and cleaned of material before each test. All particles shall be fed into the system.

8.3.2 After maintaining a constant flow rate through the test unit for a period equivalent to ten residence times of the test unit (see Note 3), the feeding of sediment shall begin at the target concentration. After all sediments have been fed into the

influent pipe, flow shall be stopped after a minimum of two residence times of the test unit.

NOTE 3—Residence time of a test unit in a given test is equal to its volume divided by the flow rate.

8.3.3 The time is recorded for the sediment feed start, feed stop, end of flush, flow stop, and when draining or pumping begins. The test unit shall be drained by means of either a clean sump pump or a drain valve mounted 30 cm [12 in.] above the floor of the test unit. The first flush from this drain valve shall be collected in a clean bucket to capture any sediment trapped in the bulkhead fitting. The rest of this drain water shall be discarded. When water level in the sump of the test unit reaches 30 cm [12 in.] above the floor, draining or pumping shall be suspended.

8.3.4 Lightly rinse all exposed surfaces into the sump. All sediments captured by the test unit shall be moved into an area of the sump away from the drain in such a manner as to minimize resuspension. After a settling time of at least 2 min following sediment disturbance, draining or pumping shall then continue in the area cleared from sediments until water is approximately 10 cm [4 in.] above the floor. Slurry shall be emptied into a series of clean barrels. Add the contents of the bucket to the barrels rinsing lightly as needed to effect complete transfer. After each barrel is full, sediment is allowed to settle for a minimum of 10 min then the water is carefully decanted and discarded (see Note 4).

NOTE 4—Some variability in technique to collect residual sediment is allowable, though as much material should be collected as practicable to minimize error.

8.3.5 All sediments and water remaining in the sump shall be collected using a wet/dry shop vacuum that has been cleaned thoroughly before its use. A clean filter shall be dried and weighed to a precision of 0.01 kg [0.02 lb] and placed in the shop vacuum before its use. This filter weight shall be used in the determination of residual mass.

8.3.6 The residual mixture of water and sediment shall be removed from the shop vacuum and the barrels with a plastic scoop and placed in a clean preweighed non-ferrous tray. A clean, fine-bristled brush may be used to sweep the surfaces of the vacuum and barrels to aid in collection. The collected sediment shall be smoothed to a maximum bed thickness of 2 cm [0.787 in.] without compaction. The shop vacuum filter shall be removed and placed in a separate clean preweighed non-ferrous tray. Trays shall be placed into a vented oven at no more than 90°C [194°F], then the temperature raised to and held at 110 ± 5°C [230 ± 9°F] for at least 24 h until a constant weight is obtained when cooled to room temperature as determined by two successive measurements taken no less than 2 h apart that show no more than a 0.1 % difference in measured mass when weighed to a precision of 0.01 kg [0.02 lb]. Weights obtained for all sediments (minus the tray and the pretest filter weights) shall be added.

9. Report

9.1 Measurements for each datum shall be recorded for the following parameters:

9.1.1 Pipe diameter(s), orientation, slope(s);
9.1.2 Specific gravity of feed material;
9.1.3 Specific gravity of feed material;
9.1.4 Temperature;
9.1.5 Test Flow Rate;
9.1.6 Influent concentration;
9.1.7 Influent dry mass of feed material; and
9.1.8 Recovered dry mass of feed material.

9.2 A scaled diagram including flow meter type and location and sediment feeder type and location shall be included with reported results. All recorded times shall be reported.

9.3 Unit removal efficiency for the tested material at a given flow rate shall be determined using:

$$\eta(\%) = (M_o/M_i) \times 100 \quad (3)$$

where:

η = removal efficiency,
M_o = mass collected from sump of test unit, and
M_I = net mass added to the system (feed—residuals).

10. Precision and Bias

10.1 The precision and bias of this test method will be available within five years.

11. Keywords

11.1 discharge; filters; flow; hydraulic capacity; scour or resuspension; sediments; specific gravity; velocity